

## REMARKS

After this response, claims 23-43 and 45-88 are pending; claims 1-22 and 44 are withdrawn; claim 89 is cancelled. In addition, claims 23-33, 35-38, 41, 43, 46-49, 51, 55-60, 62-66, 68-69, 71-73, 75-77, 79, 81-82, and 84-88 are amended.

### Claim Amendments

Claims 41, 43, 56, 58, 60, 71, 73, 85 and 87 are amended to include “ferrate(V) and/or” in addition to “ferrate(VI).” The addition of “ferrate(V)” to the claims is supported by lines 10-16 on page 13, and lines 19-21 on page 28. Lines 10-16 on page 13 state that

*“As a second disproportionation reaction, it is believed that two Fe(V) ions, either present from the reactions at Vmax, or from the Fe(IV) disproportionation reaction just mentioned [at Vmin], disproportionate into one Fe(VI) ion, which, being water soluble, diffuses into solution as final product, and into one Fe(IV) species which stays within the solid oxide film to react further in the first disproportionation reaction, thereby reducing the extent of film thinning somewhat by the first disproportionation (theoretically by 25% on a contained iron ion weight basis).” (Emphasis added)*

This suggests that Fe(V) ions are produced at both Vmax and Vmin stages of this invention. Lines 19-21 on page 28 further state that “on exiting the production cell, the electrolyte carrying soluble Fe(VI) and *a small amount of Fe(V)* may optionally be sent through a “finishing” or “polishing” cell to convert at least a part of this Fe(V) into Fe(VI) product.” Therefore, the specification supports the addition of ferrate(V) as one of the products of the present invention.

Claims 23, 46, 63, and 73 are amended to replace the phrase “substantially more electrolyte (or electrolyte solution) flows past the anode than the cathode” to the phrase “the flow rate of the electrolyte (or the electrolyte solution) is substantially higher near

the anode than near the cathode.” Similarly, claims 28-33 change the word “amount” to rate”. The amendments regarding the flow rate of the electrolyte solution are supported by lines 2-8 on page 37, Example 6 on page 55, and lines 4-11 on page 56 of the specification. Lines 2-8 on page 37 of the specification disclose that “the screen helps to restrict the flow of electrolyte to the anode side.” The invention is disclosed on the same page and in Example 6 to have only one electrolyte inlet at the anode side. As such, the flow rate of electrolyte is higher near the anode surface than near the cathode surface. Example 6 further provides a closed valve to the exiting catholyte line to reduce flow of the electrolyte solution across the cathode. Lines 4-11 on page 56 state that “flow rate of electrolyte near anode is much greater than that near cathode.”

Claims 73 and 87 are amended to specify that the electrolyte solution comprises “at least one hydroxide.” The amendment is supported by lines 11-12 on page 5 of the specification.

Claims 36, 43, 68, and 79 are amended to state that “the electrolyte solution comprises an alkaline solution of the hydroxide.” The amendment is supported by lines 14-15 on page 33 of specification, which state that “[t]he electrolyte is typically an alkaline solution of a metal ion hydroxide or metal ion hydroxides, or the equivalent.”

Claims 37, 51, and 69 are amended to either “the electrolyte solution comprises NaOH, KOH, or combinations thereof” or “the hydroxide is selected from a group consisting of NaOH, KOH, or combinations thereof.” The amendments are supported by lines 4-5 on page 5 and line 26 on page 24 of the specification.

Claims 55, 62, and 84 are amended to state that “a cell current ( $I_{cell}$ ) at the minimum voltage is less than 5% of an  $I_{cell}$  at the maximum voltage, and the  $I_{cell}$  is

greater than 0.” The amendments to claims regarding the values of the  $I_{cell}$  at the  $V_{min}$  are supported by lines 4-8 on page 21 of the specification, which state that “[t]he  $V_{max}$  voltage is maintained for a selected time ( $t_1$ ), set by the wave form frequency, and then dropped to  $V_{min}$  (Curve C and D of Fig. 1A) over periods  $t_2$  and  $t_3$ , which essentially results in a zero *electrolytic current, i.e., < 5% and normally < 1% of the total current flow at  $V_{max}$ .*” (Emphasis added)

Further, the addition of the phrase “and the  $I_{cell}$  is greater than 0” is supported by lines 26 to 27 on page 25 of the specification, which state that “ $V_{cell}$  at about 0-2.1 volts, preferably 1.7 volts, with  $I_{cell} = 0.001$ -1.0 A, (i.e. *very low current density but not zero*)” (emphasis added).

Claims 59 and 81 are amended to replace the phrase “ the minimum voltage is a voltage that substantially overcomes passivation at the anode” to the phrase “the minimum voltage is a voltage that ensures the passivation of the anode is substantially avoided.” The amendment is supported by lines 4-9 and 14-31 on page 17 of the specification. Lines 4-9 on page 17 state that

“ $V_{min}$  is controlled just low enough to slow or stop the dissolution of iron metal anode, to *suppress the formation of Fe(III)/Fe(IV) oxide layer thickness*, but *high enough to maintain oxidizing conditions at the anode surface to prevent side reactions taking place*, especially the reactions between the product, ferrate(VI) ions with reduced forms of iron, i.e. metallic iron and/or divalent Fe, Fe(II) which would quickly result in formation of a passivity layer of Fe(III) oxide on the surface of the anode.” (emphasis added)

This statement is also restated and supported by lines 14-31 on page 17, which further explain and support the amendment. Specifically, lines 14-16 on page 17 disclose that

“ $V_{min}$  is the voltage across the anode and cathode above which the conversion of Fe(0) to Fe (III) and *Fe(VI) oxides is thermodynamically favored*, but is very

slow kinetically, *so that oxide film formation is substantially depressed.*”  
(Emphasis added)

Claims 60 and 82 are amended, in which the word “exceeds” is replaced by “meets or exceeds.” The amendment is supported by lines 6 to 9 on page 18 of the specification. Lines 6 to 9 on page 18 disclose that “V<sub>max</sub>, as used herein, is the voltage across each anode and cathode of the invention *that is at or above* the voltage and current density where the iron anode dissolves electrolytically at a fast rate, and where the lower oxidation states of iron, Fe(0) through Fe(V), are converted to Fe(VI) quickly.”  
(Emphasis added)

Claims 56, 71, and 85 are amended to (1) replace the word “filtering” with the word “harvesting;” and (2) add the phrase “wherein the resulting electrolyte solution contains substantially no ferrate(V) and/or ferrate(VI).” The first amendment regarding the word “harvesting” is supported by lines 27-30 on page 7, and lines 28-29 on page 19 of the specification. Lines 27-30 on page 7 disclose that “[f]errate(VI) was harvested at four intervals shown on the graph starting at about minutes, 1100 minutes, 2300 minutes and 3900 minutes.”

The second amendment regarding the resulting electrolyte solution is supported by lines 18-20 on page 15 of the specification, which state that “[c]ontinuous harvesting of ferrate(VI) product enables the electrolyte to be recirculated through the production cell(s) *with little or no ferrate(VI) ion content*” (emphasis added).

Claims 57, 72, and 86 are amended to replace the word “filtered” with “resulting” in front of “electrolyte solution.” The amendments are done to be consistent with the

amendments in claims 56, 71 and 85 respectively; and they are supported by lines 18-20 on page 15 of the specification.

Claims 23-33, 38, 43, 46-49, 63-66, 73, 75-77, and 87-88 are also amended to correct grammatical, typographical, and antecedent errors.

Claims 25, 28, 35, and 38 are amended to increase the clarity of the claims so as to satisfy the written description requirement of 35 USC 112. For example, claim 25 is amended to delete the phrase “and preferably located beneath the anode.”

#### Claim Defects

The examiner requires restriction to one of the following inventions under 35 U.S.C. 121:

- I. Claims 1-22 (Group I), drawn to electrochemical cell.
- II. Claims 23-43, 45-89 (Group II), drawn to method of producing ferrate(VI).
- III. Claim 44, drawn to electrolyte composition.

Applicant elects Group II claims. Therefore, reconsideration and further examination of Group II claims, namely, claims 23-43 and 45-89, are respectfully requested.

The examiner is authorized to communicate with the undersigned attorney by email by the following recommended authorization language: Recognizing that Internet communications are not secure, I hereby authorize the USPTO to communicate with me

concerning any subject matter of this application by electronic mail. I understand that a copy of these communications will be made of record in the application file.  
(authorization pursuant to MPEP 502.03)

Respectfully submitted,

January 9, 2012  
Date of Signature

/Yimei C Hammond/  
Yimei C. Hammond, Reg. No. 56,323  
KREMBLAS & FOSTER  
7632 Slate Ridge Blvd.  
Reynoldsburg, OH 43068  
Voice: 614/575-2100  
Fax: 614/575-2149  
email: yhammond@ohiopatent.com